

Rules for the Semantic Web

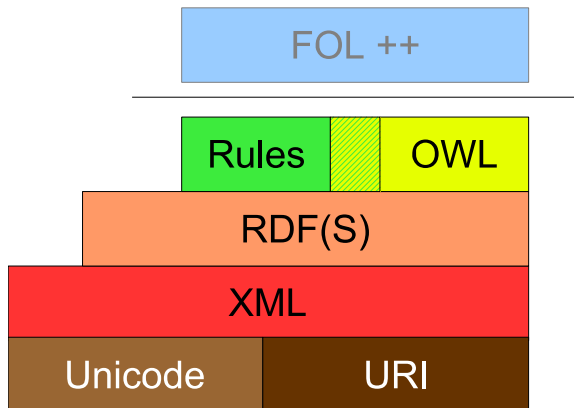
The WSML Approach

Jos de Bruijn
jos.debruijn@deri.org

Digital Enterprise Research Institute (DERI)
National University of Ireland, Galway
University of Innsbruck, Austria

April 27, 2005

Web Rule Language in its Context



Outline

The Web Service Modeling Language WSML

- WSML Language Variants

- WSML Syntax

- WSML Logical Expressions

- WSML Exchange Syntaxes

Key Features of WSML

Layering on the Semantic Web

Conclusions

Outline

The Web Service Modeling Language WSML

- WSML Language Variants

- WSML Syntax

- WSML Logical Expressions

- WSML Exchange Syntaxes

Key Features of WSML

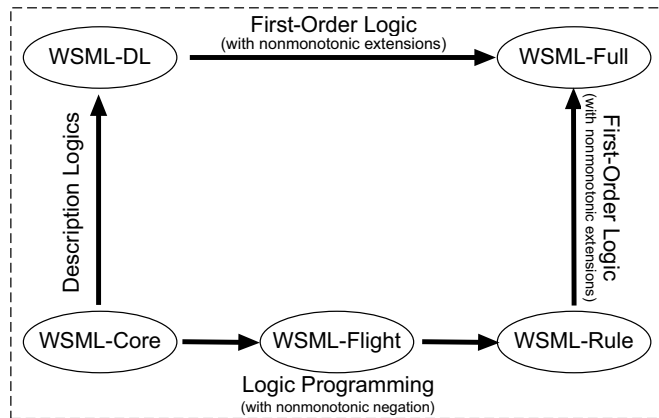
Layering on the Semantic Web

Conclusions

The Web Service Modeling Language WSML

- ▶ A language for the Semantic description of Web Services
- ▶ Based on the Web Service Modeling Ontology WSMO
 - ▶ Ontologies
 - ▶ Web Services
 - ▶ Goals
 - ▶ Mediators
- ▶ Disregard Web Service-related aspects in this presentation
- ▶ Semantics based on well-known logical language paradigms:
 - ▶ Description Logics
 - ▶ Logic Programming
 - ▶ Frame Logic
- ▶ WSML distinguishes between:
 - ▶ Conceptual modeling
 - ▶ Logical expressions

WSML Language Variants



Prologue

By Example

```
// Specification of the WSML variant
wsmlVariant _" http://www.wsmo.org/wsml/wsml-syntax/wsml-flight"

// Namespace prefix declaration
namespace { _" http://www.example.org/example#" ,
  dc _" http://purl.org/dc/elements/1.1/" }

// WSML specifications
ontology _" http://www.example.org/exampleOntology"
  [...]
goal _" http://www.example.org/exampleGoal"
  [...]

etc...
```

WSML Specification

A WSML specification has the following structure:

- ▶ Type of specification (Ontology/Web Service/Goal/Mediator)
- ▶ Header
 - ▶ Non-Functional Properties
 - ▶ Imported Ontologies
 - ▶ Used Mediators
- ▶ Content of the specification

Ontologies

Header

```
[.. prologue ..]
```

```
ontology _" http://www.example.org/ontologies/example"
```

```
  nonFunctionalProperties
```

```
    dc#title hasValue "WSML example ontology"
```

```
  endNonFunctionalProperties
```

```
  importsOntology {_" http://www.wsmo.org/ontologies/location" }
```

```
  usesMediator {_" http://www.wsmo.org/mediators/" }
```

Ontologies

Concepts

- ▶ Form the basic terminology of the domain of discourse
- ▶ May be organized in a hierarchy (using **subConceptOf**)
- ▶ Has a number of attributes:
 - ▶ Attributes have a type:
 - ▶ Type constraint (**ofType**)
 - ▶ Type inference (**impliesType**)
 - ▶ Attributes may have cardinality constraints
 - ▶ Attributes may have a number of features:
 - ▶ Transitive
 - ▶ Symmetric
 - ▶ Reflexive
 - ▶ Inverse of another attribute

Ontologies

Concepts - example

```
concept Person subConceptOf {Primate, LegalAgent}
```

```
nfp
```

```
// Related axiom
```

```
dc#relation hasValue personUncle
```

```
endnfp
```

```
// A functional attribute (maximal cardinality=1)
```

```
hasName ofType (0 1) _string
```

```
// hasParent is the inverse of hasChild
```

```
hasChild inverseOf(hasParent) ofType Person
```

```
hasParent ofType Person
```

```
hasBrother ofType Person
```

Ontologies

Relations

- ▶ Inspired by relations in mathematics
- ▶ Have arbitrary arity
- ▶ May have typing associated with its arguments
- ▶ May be organized in a hierarchy (using **subRelationOf**)

relation Marriage (ofType Person, ofType Person, ofType _date)

nfp

dc#description **hasValue** "Marriage is a relation between two persons, which are the participants in the marriage, and the date in the marriage."

endnfp

Ontologies

Instances

- ▶ Are the objects in the domain
- ▶ May be member of one or more concepts
- ▶ May have a number of attribute values associated with it

instance john **memberOf** Person

nfp

dc#description **hasValue** "The person John Smith"

endnfp

hasName **hasValue** "John Smith"

Ontologies

Relation Instances

- ▶ Are tuples in a relation

relationInstance Marriage(john,mary,_date(2005,03,03))

nfp

dc#description **hasValue** " John and Mary married on 2005-03-03."

endnfp

Ontologies

Axioms

- ▶ Refine concept and relation definitions in Ontologies using logical expressions
- ▶ Add arbitrary knowledge and constraints
- ▶ Entry point for logical expressions, rules in ontology
- ▶ Allowed logical expressions depend on WSML variant

axiom personUncle

nfp

dc#description **hasValue** "The brother of a person's parent is that person's uncle."

endnfp

definedBy

?x[hasUncle **hasValue** ?z] **impliedBy** ?x[hasParent **hasValue** ?y] **and** ?y[hasBrother **hasValue** ?z].

Logical Expression syntax

- ▶ Used for refining Ontologies and specifying Web Service functionality
- ▶ Allow to use the full expressive power of the underlying logic
- ▶ Frame syntax (F-Logic)
- ▶ Logic Programming constructs
 - ▶ Negation-as-failure
 - ▶ LP implication
- ▶ Variables are implicitly universally quantified outside the formula
- ▶ Symbols resemble natural language and are unambiguous
- ▶ WSML variants restrict allowed logical expressions

Examples

Examples

```
// a simple rule; the brother of someone's parent is that person's  
// uncle  
?x[hasUncle hasValue ?z] :- ?x[hasParent hasValue ?y] and  
?y[hasBrother hasValue ?z].
```

Examples

```
// a simple rule ; the brother of someone's parent is that person's
```

```
// uncle
```

```
?x[hasUncle hasValue ?z] :- ?x[hasParent hasValue ?y] and  
?y[hasBrother hasValue ?z].
```

```
// the same person cannot be both a man and a woman (constraint)
```

```
!- ?x memberOf Man and ?x memberOf Woman.
```

Examples

```
// a simple rule; the brother of someone's parent is that person's
```

```
// uncle
```

```
?x[hasUncle hasValue ?z] :- ?x[hasParent hasValue ?y] and  
  ?y[hasBrother hasValue ?z].
```

```
// the same person cannot be both a man and a woman (constraint)
```

```
!- ?x memberOf Man and ?x memberOf Woman.
```

```
// every person has a father
```

```
?x memberOf Person implies exists ?y (?x[father hasValue ?y]).
```

WSML XML Syntax

- ▶ Syntax for exchange over the Web
- ▶ Translation between human-readable and XML syntax
- ▶ XML Schema for WSML has been defined

WSML XML

Example

```
<!ENTITY ex "http://www.example.org/ontologies/example#" >
<!ENTITY wsml "http://www.wsmo.org/wsml/wsml-syntax#" >
<wsml xmlns=" &wsml;"
  variant="http://www.wsmo.org/wsml/wsml-syntax/wsml-flight" >
  <importsOntology>
    http://www.wsmo.org/ontologies/location
  </importsOntology>
  <concept name=" &ex;Person" >
    <nonFunctionalProperties>[.]</nonFunctionalProperties>
    <attribute name=" &ex;hasName" type="constraining" >
      <range>&wsml;string</range>
      <maxCardinality>1</maxCardinality>
    </attribute>
    [.]
  </concept>
  [.]
</wsml>
```

WSML RDF Syntax

- ▶ Interoperability with RDF applications
- ▶ Maximal reuse of RDF and RDFS vocabulary
- ▶ WSML RDF includes most of RDF
- ▶ Translation between human-readable and RDF syntax
- ▶ For logical expressions, XML literals are used

WSML RDF

Example

```

<http://www.example.org/ontology> rdf#type wsml#ontology
<http://www.example.org/ontology> wsml#variant
  <http://www.wsmo.org/wsml/wsml-syntax/wsml-flight>
<http://www.example.org/ontology> wsml#nfp _:nfp1
_:nfp1 dc#title "WSML example ontology"^^xsd:string
<http://www.example.org/ontology> wsml#importsOntology
  <http://www.wsmo.org/ontologies/location>
<http://www.example.org/ontology> wsml#hasConcept ex#Person
ex#Person wsml#hasAttribute _:att1
_:att1 wsml#attribute ex#hasName
_:att1 wsml#ofType xsd:string
_:att1 wsml#maxCardinality "1"^^xsd:integer
<http://www.example.org/ontology> wsml#hasAxiom
  ex#personUncle
ex#personUncle rdfs#isDefinedBy
  " <impliedByLP>..</impliedByLP>"^^rdf#XMLLiteral

```


Outline

The Web Service Modeling Language WSML

WSML Language Variants

WSML Syntax

WSML Logical Expressions

WSML Exchange Syntaxes

Key Features of WSML

Layering on the Semantic Web

Conclusions

Key Features of WSML

- ▶ One framework for a set of Layered Languages
- ▶ Normative, Human-readable Syntax
- ▶ Separation of conceptual modeling and logical expressions
- ▶ Semantics based on well-known formalisms
- ▶ Relation between DL and Rules through common subset
- ▶ Web Language
- ▶ Frame-based syntax

Outline

The Web Service Modeling Language WSML

WSML Language Variants

WSML Syntax

WSML Logical Expressions

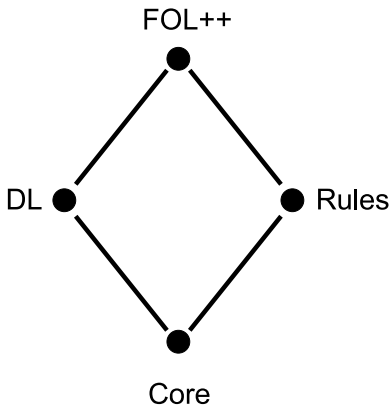
WSML Exchange Syntaxes

Key Features of WSML

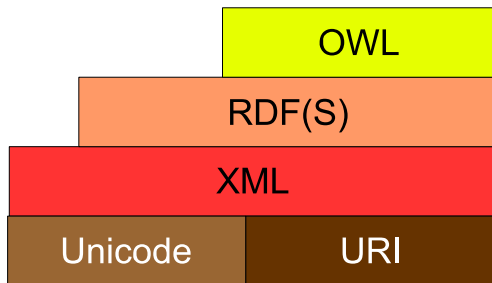
Layering on the Semantic Web

Conclusions

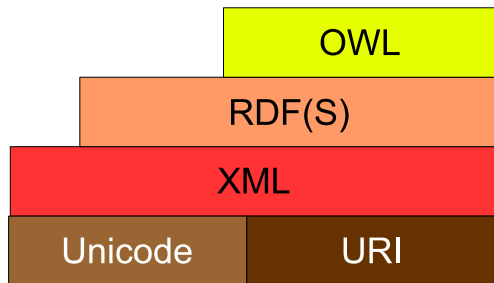
The WSML Approach to language layering



Current Languages on the Semantic Web



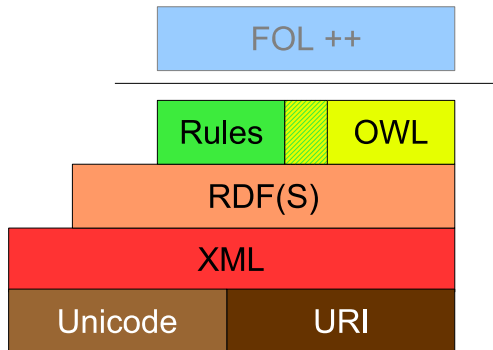
Current Languages on the Semantic Web



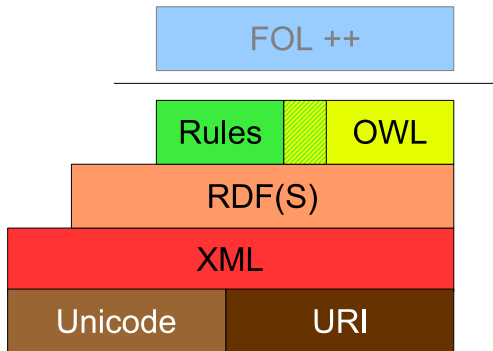
How to Incorporate rules?

- ▶ Layering Rules on top of OWL (e.g. SWRL)
- ▶ Hybrid approach (e.g. CARIN/AL-Log)
- ▶ Using a common subset for interoperation (e.g. DLP)

Common subset



Common subset



- ▶ Maintain nice properties of each of the underlying logics
- ▶ Reuse existing implementations of rules and description logic
- ▶ Allow straightforward extension in both directions

Outline

The Web Service Modeling Language WSML

WSML Language Variants

WSML Syntax

WSML Logical Expressions

WSML Exchange Syntaxes

Key Features of WSML

Layering on the Semantic Web

Conclusions

Conclusions

WSML position on a Rules language for the Web:

Conclusions

WSML position on a Rules language for the Web:

1. Relation between DL and Rules through common subset

Conclusions

WSML position on a Rules language for the Web:

1. Relation between DL and Rules through common subset
2. Rules-based ontology language

Conclusions

WSML position on a Rules language for the Web:

1. Relation between DL and Rules through common subset
2. Rules-based ontology language
3. Ontology meta-model independent from underlying logic

Conclusions

WSML position on a Rules language for the Web:

1. Relation between DL and Rules through common subset
2. Rules-based ontology language
3. Ontology meta-model independent from underlying logic
4. Separation of conceptual modeling and logical expressions
5. Normative, Human-readable Syntax

Conclusions

WSML position on a Rules language for the Web:

1. Relation between DL and Rules through common subset
2. Rules-based ontology language
3. Ontology meta-model independent from underlying logic
4. Separation of conceptual modeling and logical expressions
5. Normative, Human-readable Syntax
6. Semantics based on well-known formalisms; allows integration with existing systems

Conclusions

WSML position on a Rules language for the Web:

1. Relation between DL and Rules through common subset
2. Rules-based ontology language
3. Ontology meta-model independent from underlying logic
4. Separation of conceptual modeling and logical expressions
5. Normative, Human-readable Syntax
6. Semantics based on well-known formalisms; allows integration with existing systems
7. Web Language

Conclusions

WSML position on a Rules language for the Web:

1. Relation between DL and Rules through common subset
2. Rules-based ontology language
3. Ontology meta-model independent from underlying logic
4. Separation of conceptual modeling and logical expressions
5. Normative, Human-readable Syntax
6. Semantics based on well-known formalisms; allows integration with existing systems
7. Web Language
8. Frame-based syntax

Conclusions

WSML position on a Rules language for the Web:

1. Relation between DL and Rules through common subset
2. Rules-based ontology language
3. Ontology meta-model independent from underlying logic
4. Separation of conceptual modeling and logical expressions
5. Normative, Human-readable Syntax
6. Semantics based on well-known formalisms; allows integration with existing systems
7. Web Language
8. Frame-based syntax

WSML resources

<http://www.wsmo.org/wsml/wsml-syntax#>

Web Rule Language in its Context

